WELLCOME INSTITUTE
LIBRARY
Coll. welTROmec
Call No. pam
WC715
1897
R72o

ON THE INFLUENCE OF VARIATIONS OF THE GROUND-WATER LEVEL ON THE PREVALENCE OF MALARIAL FEVERS

Leonard ROGERS

1897

(Scientific Memoirs of I.M.S.Officers.)

Scientific memoirs by medical officers
of the Army of India. Pt. 10.

Scientific Memoirs of I.M.S. Officers. 1897. Pt X.

[8]

On the influence of variations of the ground-water level on the prevalence of Malarial Fevers.

BY

SURGEON-CAPTAIN LEONARD ROGERS, M.B., B.S., LOND., F.R.C.S., ENG., I.M.S.

IN a paper read before the Calcutta Medical Society in January 1896, I showed that the number of fresh cases of malarial fever in the men of the 11th Bengal Infantry rose and fell with the rise and fall of the ground-water level of the lines in which they were living, to such a degree that the curve illustrating the four rises and falls of the ground-water, which occurred during the course of the rains, was closely followed by the curve of the fever prevalence. The two were practically parallel, and on two occasions a fall of only seven inches, when the water was 16 and 8 feet respectively from the surface of the ground, during three and four daily periods, was accompanied by falls of the fever to ½ and ⅓ respectively of its rate during the preceding rises, facts which could only be explained on the supposition that the infection was due to the inhalation of *plasmodium malariæ* which had been carried up into the atmosphere by the displacement of ground air by the rising water. The further fact that an examination of the blood of 76 consecutive cases of the fever, in each of which one specimen of blood was examined with an oil emersion lens for an equal time, showed that the organism was found in 50 per cent. of the cases which began during periods when the ground-water was rising, but in just under 20 per cent. of those which occurred when the water was falling, doubtless due to the parasite being present in larger numbers in the former series of cases, (as an analysis of the symptoms proved that all the cases were of the same nature), also supported very strongly this explanation of the curves. In order to further test the question, the figures of the monthly fever rate for the last ten years among the men of the various regiments which were stationed in Doranda, together with the monthly rainfall of the same period, were obtained, and the charts which accompany this paper were worked out and have revealed several points of interest which I propose to briefly point out in this communication.

The upper diagrams represent the monthly number of admissions for fever in the several years, while underneath them will be found the monthly rainfall. It will be seen at a glance that, with the exception of the year 1892, the great bulk of the fever occurs in the rainy season, and a closer examination shows that, although the rains nearly always begin in June, the fever does not

increase to any marked extent until July. This is due to the fact that, at the beginning of the rains, in this place, the ground-water is always from 35 to 40 feet from the surface of the ground, and, in the year 1895, was still 28 feet down at the end of June in spite of almost 10 inches of rain having fallen during that month. As soon, however, as there has been heavy rain in July on the top of that of June, the fever begins to rise and continues to be prevalent as long as, or rather longer than, the rain lasts, declining again in October, or even in September in such years as the rains terminate early, as in 1891 and 1887, but going on into November or December in years in which the rains continue later than usual as in 1889 and 1893, in the latter of which there was very heavy rain in September.

A further study shows that there are two main factors on which the amount of fever in any given year depends. These are, firstly, the amount of the rain, and, secondly, the regularity or irregularity of its distribution. On these depend the height to which the ground water will rise and the rapidity and amplitude of its variations of level; and, if my supposition that the amount of fever in any given year in this place will depend on the amount of displacement of the ground air, carrying up the organisms into the atmosphere, is correct, then the amount of fever should depend on the amount and irregularity of the distribution of the rainfall. Let us see whether this is the case or not.

If the years 1887 and 1892 be compared, it will be seen that the charts of the rainfall show much the same character, inasmuch as there was no very excessive fall in any month, but the fever rate was very high in the former year, while there was practically no fever at all during the rains in the latter. If, however, the quantity of rain be noted, it will be seen that in 1887 the rainfall was considerably in excess, amounting to over 70 inches, while in 1892 it was less than normal, being only 52·53 inches. The water must, then, have risen much higher in the former year. It will also be noticed that the rains began very early in 1887, namely in May, so that the ground-water must have been very high during July and August, while, on the other hand, the rains stopped early, and so the fever rapidly fell in September and October.

Again, if we compare 1892 with 1894, it will be seen that in the latter year, not only was the rainfall in excess, but it was also unevenly distributed, so that there was over 19 inches in both July and August. Here, then, we have both factors well marked, and it is worthy of note that, in this year, the fever is higher than any other year of the series, and that there was 12 times as much fever this year as there was in 1892; and, if only that in the rainy seasons be counted, which, for reasons which will appear later, gives the most correct comparison, then it was 30 times as much. The practical absence of fever in the rainy season of 1892 remains to be explained, as it is very extra-

Digitized by the Internet Archive
in 2018 with funding from
Wellcome Library

https://archive.org/details/b30476471

ordinary. It has already been mentioned that there may be heavy rain in June, or even in both May and June, as in 1887, and yet no marked increase of fever will occur until July. This shows that the increase does not depend on either the variations of temperature, which will be most marked at the beginning of the rains, or on chills produced by getting wet (a very strong point in favour of my theory), and it has already been shown that the absence of fever in June is due to the water being too low down to cause it during that month. Now, in the year 1892, not only is the rainfall deficient, but it is also very evenly distributed, not quite 12 inches having fallen during any one month, so that it is evident that in this year the water-level must have been lower and more constant than in any other year of the series, and hence the nearly complete absence of fever. Moreover, it will be seen that there was only 3·31 inches of rain between October 1891 and May 1892, so that the water-level must have been unusually low at the beginning of the rains in this year (at least forty feet), which, again, is an important factor, as it would lessen the influence of the small amount of rain that actually did fall, in the rainy season, in raising the water-level. Thus, it is evident that everything combined to make the conditions least favourable for the incidence of fever during that year. On the other hand, there was a low rainfall in 1890, but it was more unevenly distributed, and there was more rain in March and May, so that, although the fever in the rains (for that in the early months of the year is due to an entirely different cause) was less than the average, yet it was greater than in 1892. Thus, all the peculiarities of the distribution of the fever during the rainy seasons are easily explained on the above-mentioned supposition, but that which occurs in the cold weather months does not come under the same laws, and remains to be considered.

That the amount of rain in the early months of the year does not influence the fever rate during the same months, is evident from a comparison of the small amount of fever during the first five months of 1895, in spite of unusually heavy rain during the same period, with the high rate of fever in the same months of 1889, accompanied by a low rainfall. For a long time I was at a loss to account for the considerable variation in the amount of fever in the early months of the different years, although the fact that it did not coincide with the rainfall was not surprising, seeing that the ground-water level during the cold weather months of 1895-96, the years in which I took measurements, reached a depth of 30 feet from the surface by the end of November, and remained at below that level until the onset of the next rainy season, and the very slight variations which it undergoes at that depth could not be expected to influence the fever rate. In fact I believe that the malarial organisms will be found in largest numbers in the damp earth at or just above the water level, and hence, during the cold weather, will be too far down to be able to gain access to the air in large enough number to cause many fresh

infections. The following explanation of the cold weather incidence of the fever in Doranda supports this supposition.

If the charts be examined from year to year as one continuous record, it will be found that the amount of fever in the early months of one year is, in the majority of instances, in proportion to its prevalence during the rainy season of the year before. Thus after the high rate of fever during the rains of 1887, there was a correspondingly large amount in the early part of 1888, and on the other hand, after the very low prevalence of fever in the rainy season of 1892 there was an equally low rate in the first half of 1893. There are, however, two very marked exceptions to this rule, namely, when the comparatively slight prevalence of 1888 was followed by a high cold weather rate in 1889, and when the very high rate of 1894 was followed by very little fever early in 1895. These instances form, however, a true case of the exceptions proving the rule, for, in January of both 1889 and 1895 and also in 1892, the regiments were changed, and as is shown in the accompanying table the fever in these, and also in 1886 and 1892, was actually proportionate to the amount of fever that the incoming regiments had had in the previous rainy season in other provinces. Again, in the rains of 1895, just 25 per cent. of the men of the 11th B. I. suffered from fever, that is 1 in every 4, yet of those who had fever in December 1895, and January 1896 out of 22 cases, no less than 15 or very nearly $\frac{3}{4}$ of them had had fever in the previous rains, and several of them had had it two or three times.

Regiment.	Reached Doranda.	Previous station.	Former fever rate.	Fever first 6 months in Doranda.
IX B. I.	January 1889.	Barrackpore and Chittagong.	480 per 1,000	58 cases.
XII. B. I.	January 1892.	Benares	267·1 per 1,000	20 cases.
XI. B. I.	January 1895.	Bareilly.	116·3 per 1,000	9 cases.

It is also worth noting that two or three dry years in succession, as in 1889 to 1892, have a decreasingly small fever rate, while two wet years such as 1893, 1894 show a progressively high rate.

The above facts then prove that the great majority of the cases of fever which occur in winter in Doranda are recurrences and not new infections, and the whole yearly incidence of fevers here are easily explained on the theory that I have advanced. That malarial fevers are commonly got through the inhalation of air containing the organisms has of course long been known, especially in connection with the drying up of marshy ground, but the above observations seem to show that this is the usual mode of infection also in places on higher

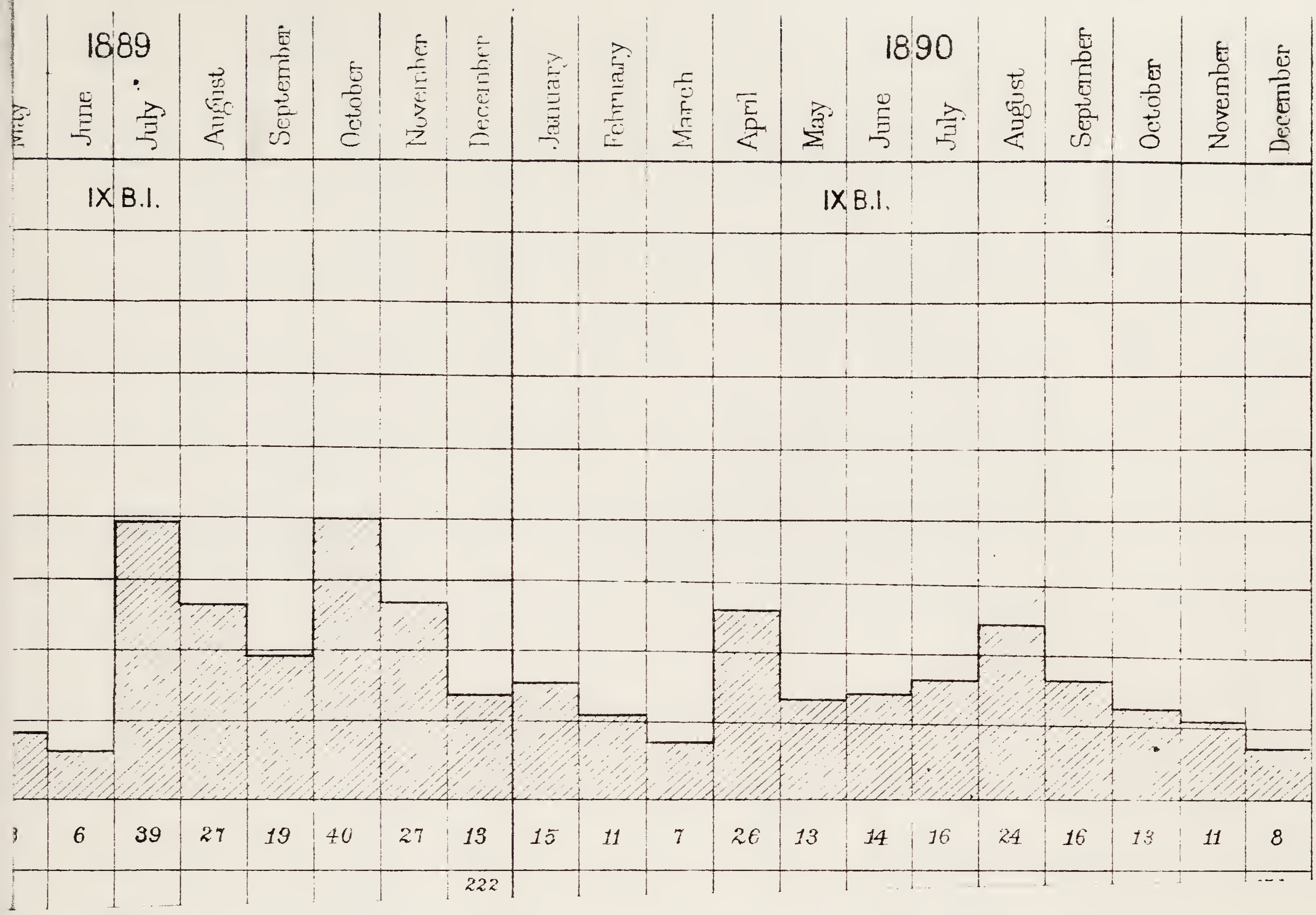
ground, and when the water is many feet from the surface, and that this mode of infection is a much commoner one than that by drinking water, although the latter doubtless also occurs. As the *plasmodium malariæ* is endowed with amœboid movement, the very thin walls of the alveoli of the lungs and of the pulmonary capillaries will offer but little resistance to its entry into the blood. I would also suggest that the organisms might also just as easily make their escape in the same way, and to my mind this is a much more satisfactory theory to explain how the organisms of malaria leave the body in order to resume their external life, than the supposition of Dr. Manson that the interference of the mosquito, or other sucking insect, is necessary to assist its escape, if, indeed, there is any necessity for such an escape at all, seeing the unlimited number of these parasites there must be in the soil of malarious districts. I may add that I have got complete confirmation of the relationship between the rise and fall of the ground-water and the occurrence of fresh cases of malaria, in the Nowgong district of Assam, but here there appears to be some evidence that, during a long break in the rains, there may be a rise of the fever rate in connection with the drying up of the soil, as, indeed, might be expected from the fact that the ground-water is much nearer the surface in some parts of that district than it is in Doranda. In fact it is intermediate between places where the ground-water is very low and where it is very high and the seasonal fever incidence is intermediate between what it is in the case of the two extremes.

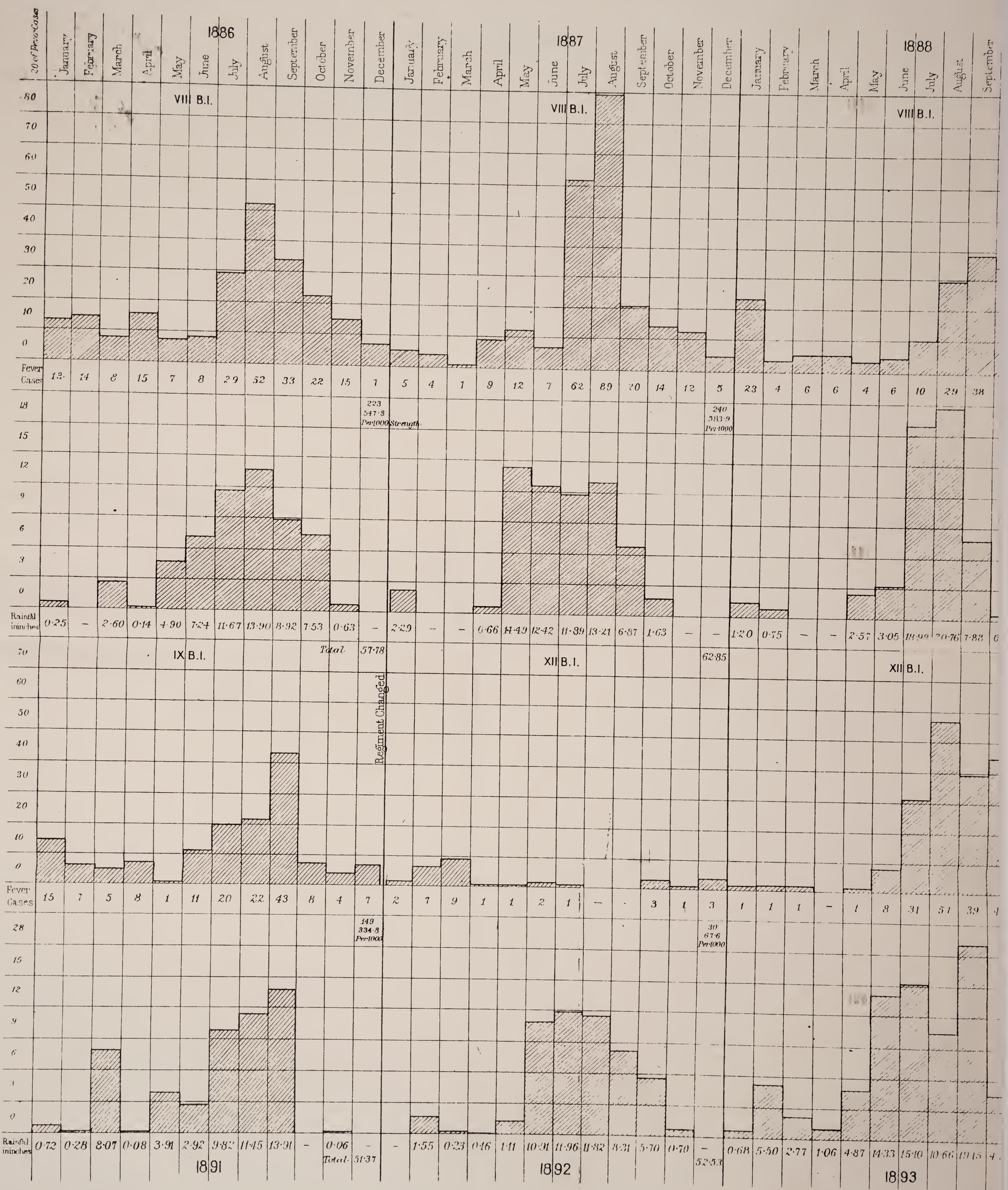
The exact incidence of the malarial fevers in the rainy season, with recurrences extending into the cold weather months in proportion to the amount of fever in the rains, as shown in the accompanying charts, only happens in places where the ground-water level is low in the dry seasons and rises rapidly during the rains, and it is worthy of note that chronic malaria is very rare in such districts, because new infections only taking place to any extent in the rains, there are eight months in which the poison may be eliminated from the system before more is likely to be absorbed. On the other hand in places like lower Bengal and Sylhet, where the water is always much nearer the surface (in the latter place it was only five feet from the surface at the end of the dry weather this year), the main incidence of the fever is during the drying up after the rains, and chronic malaria is of frequent occurrence. The former fact is accounted for on the supposition that, when the saturated ground is drying under the influence of the autumn sun, much of the water is evaporated into the air, and this carries up with it the infecting organisms which are living in large numbers close to the surface of the ground in the warm moist soil, and they are then breathed in as before described. The water, and consequently the organisms also, being near the surface all the year round, new infections can constantly take place and hence chronic malaria is common in such parts. The further fact that in such places as Dacca and Sylhet the amount of fever is less when a great part of the ground is submerged, also points

to the conclusion that malarial infection is mainly through the air, for at such times the organisms would less readily find their way into the air by either displacement from the ground or by evaporation from a saturated soil. In short, I am inclined to think that all the main facts with regard to the seasonal incidence of malarial fevers are explainable in great part by the height and variations of the ground-water level, but as these vary in the most extraordinary way in even very similarly situated places, all the local circumstances have to be taken into account before the explanation which I have here advanced is rejected in any given case. A good instance of such a variation, which has also a practical bearing, happened in the case of the Doranda lines with which I will conclude this paper.

On the same day that the water level in the regimental lines was only 5¼ feet from the surface of the ground, it was 25 feet down only 300 yards away on the parade ground, although there was not a difference of more than three feet in the level of the two places. The high level in the lines was due to a road having been made with only one small culvert in it, (and that on too high a level) which obstructed the surface drainage of the lines. This is to be remedied on my suggestion as far as possible, but unfortunately it could not be done before the rains of this year set in, so I am unable at present to give the result of this measure. It shews, however, what apparently slight things may modify very materially the health of a site, for I have no doubt whatever that if the lines had been where the parade ground is, there would not have been half the amount of fever that there now is in the wet season. In 1894, for instance, the water reached the level of the mouth of one of the wells, a rise of from 35 to 40 feet from the lowest level at the end of the hot weather. Until measurements of the ground-water were taken there was no suspicion that the surface drainage was so deficient. The lesson is obvious, and I would suggest that such measurements should be taken, for a year if possible, before a site for a station or cantonment is chosen in any malarious country, as this simple measure might prevent the necessity of abandoning posts after the expenditure of considerable sums of money on buildings, etc., on account of the amount of fever in the place, as has happened before now. If, for instance, two or more sites appeared to be about equally favourable, and time permitted, a well should be sunk in each and measurements taken, which would show in which site the ground-water is lowest and least variable. This site would be the least malarial.

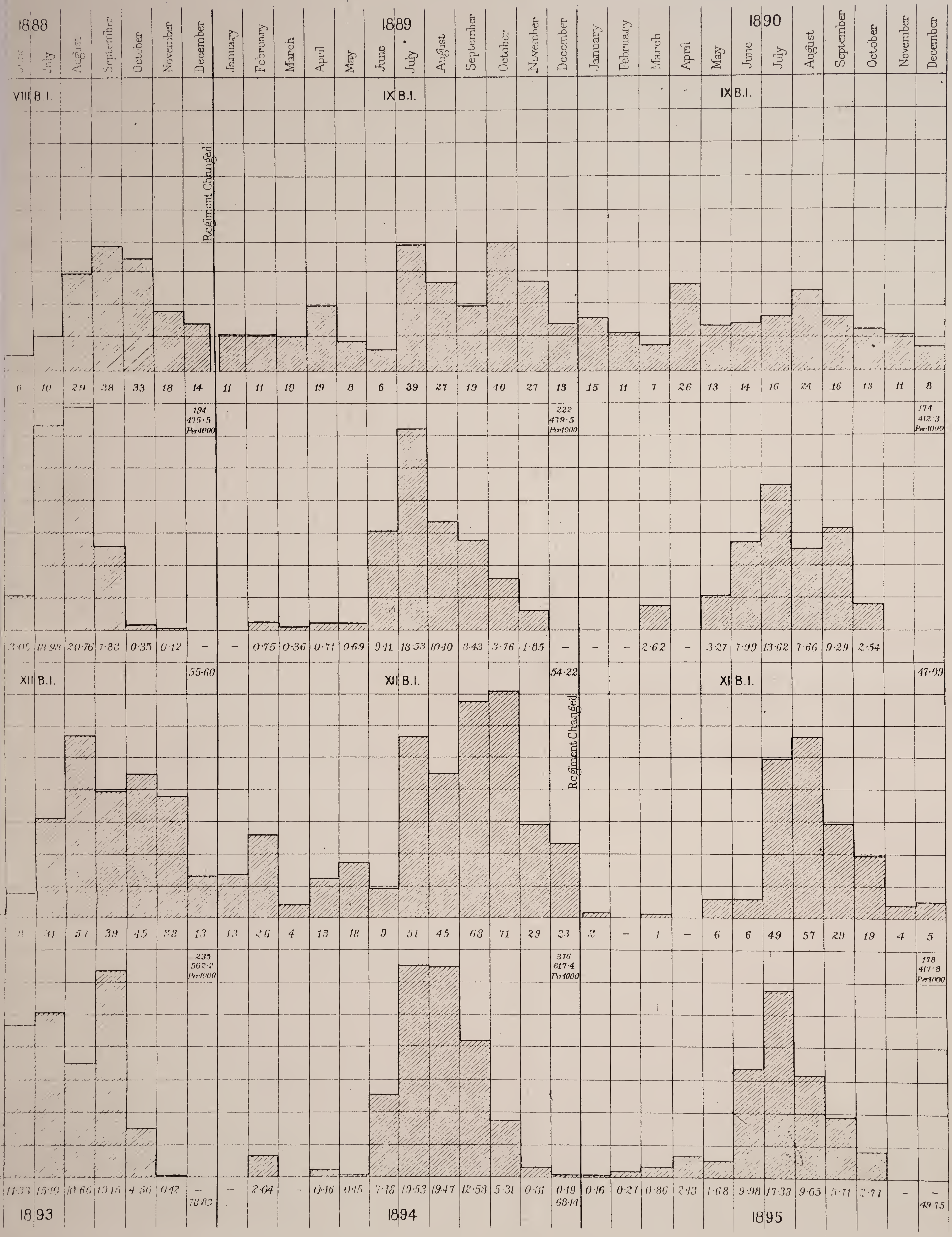
I have recently met with other instances in certain tea garden coolies' lines where by means of taking the ground-water levels, I have been able to show that the nearer the water is to the surface and the more it varies the greater is the fever rate, so that the Doranda case is not an isolated one. Many more observations in places whose ground-water levels differ widely will be necessary before a general law of their influence on the prevalence of malarial fevers can be formulated, but it is hoped that this contribution may lead to renewed attention being given to the subject.


1889
June
July
August
September
October
November
December
January
February
March
April
May
1890
June
July
August
September
October
November
December
IX B.I.
IX B.I.
6
39
27
19
40
27
13
15
11
7
26
13
14
16
24
16
13
11
8
222



Lith by A. G. Mukerjei.

DIAGRAM ILLUSTRATIVE OF FLUCTUATIONS IN THE
AND IN PREVALENCE OF FEVER IN REGIM



CTUATIONS IN THE LEVEL OF THE GROUND-WATER
OF FEVER IN REGIMENTS IN DORANDA.

Sc. Mem. Part X.